RESEARCH HIGHLIGHTS

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Technical Series 02-100

FINAL ASSESSMENT OF CONSERVATION CO-OP'S GREYWATER SYSTEM

Introduction

Before greywater treatment systems can become a common feature in residential buildings, field testing is essential. In fact, the National Building Code currently prohibits the use of these systems in residential buildings, except on an experimental basis. Their installation requires special permits and rigorous monitoring.

Conservation Co-op, centrally located in Ottawa, agreed to participate as a pilot demonstration site for a Canada Mortgage and Housing Corporation (CMHC) greywater treatment project. CMHC is interested in researching these systems to gain a better understanding of design and operational and maintenance needs, in order to encourage the adoption of water conservation technologies and practices in the residential sector. In addition to CMHC, the Municipality of Ottawa, the Ontario Ministry of Environment and Conservation Co-op staff and residents contributed to the project's undertaking.

Conservation Co-op, built in 1995, is a four-storey, 84-unit housing co-operative where residents are committed to environmentally sustainable practices. The co-op incorporated some unique features, such as a greywater treatment system and its monitoring equipment.

Greywater for this demonstration site is defined as water collected from the shower and bathtub. The building design allowed for eight units to be dual plumbed, which added separate greywater effluent pipes to deliver the greywater for treatment to the system in the basement. Return supply lines from the treatment system, redirected the water back to the eight units as the water supply for toilet flushing. The water reuse plumbing system was active only when connected to the greywater treatment system. Otherwise, the toilets were supplied with water from the city.

In the summer of 1996, water meters were installed on the city water supply lines to the toilets to monitor water consumption for two months. This data and a literature review of greywater treatment technologies were used to select two treatment options—slow sand filter and rapid sand filter—for testing. The treatment facility was installed the following summer

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The pilot study was not as successful as anticipated. In 1999, a new treatment process was designed using a rapid pressure filter system, replacing the two filtration technologies tested in 1997. The treatment system was completed and commissioned for use in August 1999, but it immediately ran into a series of problems including failure of system pumps and a valve. The system was shut down, resulting in odour problems, scum and accidental ozone release. A review of the operation and treatment system was undertaken in December 2001 by NovaTec Consulting in order to recommend corrective action. The work included 1) a review of documentation, 2) interviews with key individuals involved in the design, installation and operation of the treatment system, and 3) site inspection of the treatment system. NovaTec Consulting's recommendations are reported in subsequent sections of this highlight.

The greywater treatment system at Conservation Co-op

Residential wastewater is commonly grouped into three classifications:

1. blackwater—from toilets;
2. dark greywater—from kitchen sinks, clothes washers and dishwashers;
3. light greywater—from showers, tubs and bathroom sinks.

In designing or selecting effective treatment processes for any of these, it is important to recognize that all three contain significant quantities of contaminants. They therefore require all of the following treatments:

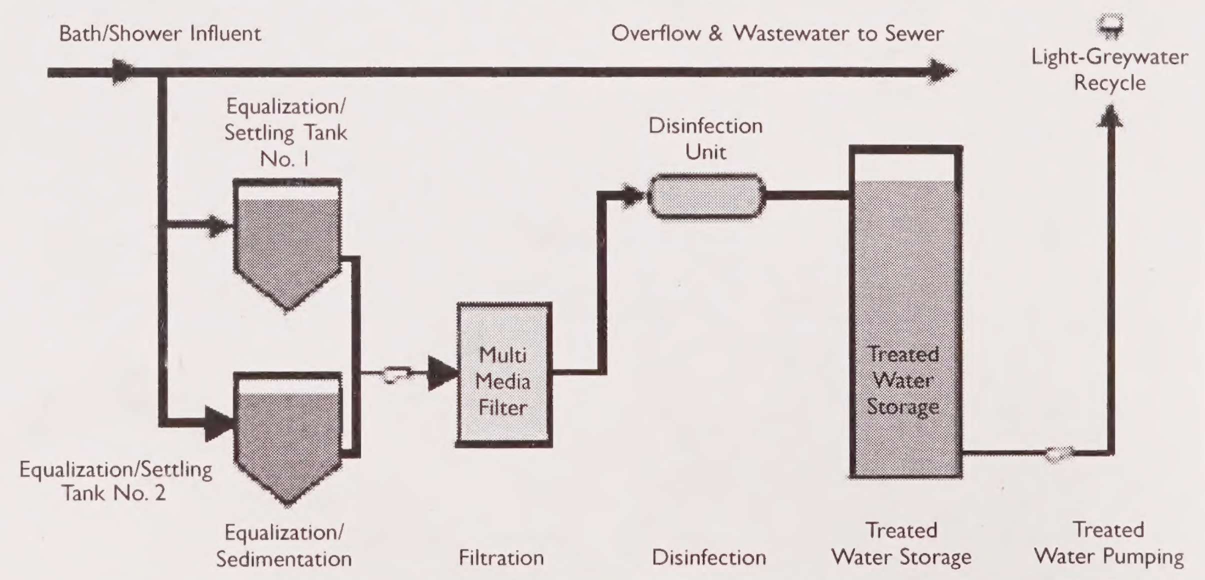
1. screening and settling to remove solids;
2. flotation and skimming to remove oils, grease, fats and scum;
3. growth of beneficial bacteria under controlled conditions to remove soluble organic compounds;
4. disinfection to kill pathogens (bacteria, viruses and parasites).

Conservation Co-op's treatment system consisted of the following key components (see Figure 1):

- *screening* - Basket screens (1 mm mesh), located at the top of each of the two equalization-sedimentation tanks, trapped hair, lint and other large particles. Sodium hypochlorite pucks were used to control odours and biofouling in the filter.

- *raw water equalization* - sedimentation tanks 1 and 2 - The two large tanks removed floating oils and scum, and settled solids, and provided initial disinfection. The tanks, which had a retention time of 6 to 12 hours, filled and were pumped out on an alternating basis. The waste from this process (about 50 litres per cycle) was automatically discharged to a sewer line through a sump after each fill-draw cycle was complete.

Figure 1: Diagram of Conservation Co-op's greywater treatment system



- *transfer pump* - A small pump transferred liquid from the two raw water tanks through a multimedia pressure filter. With a design flow rate of 0.33 litres per second, it took approximately 15 minutes to pump the contents of each tank through the multimedia filter.

- *multimedia pressure filter* - As the raw water moved through the filter, it passed through decreasing sizes of granular media (anthracite, fine sand, garnet and limestone), which filtered out particulate material. Solids trapped in the filter were removed during an automatic backwash cycle. The filters used, though, were more common in potable water treatment systems for filtering particulates, and they did not remove soluble organic (biochemical oxygen demand, or BOD) compounds.

- *ozonation* - After filtration, the water was injected with ozone to provide further disinfection, remove colour and break down organic chemicals in the water.

- *treated water tank* - The filtered and ozonated greywater was then stored in a 600-litre volume plastic tank. A distribution pump transferred water from this tank into the distribution pipe to the toilets. If the greywater treatment system was unable to keep up with the demand for reused water, additional make-up water was automatically supplied to the tank from a potable (city) water line.

- *distribution pump* - When a toilet was flushed, the resulting drop in water pressure within the distribution system was sensed, and a 0.75 hp distribution pump was activated to provide reused water to the toilet. Although the pump might have been able to supply adequate pressure and flow of water to a single toilet, it could not adequately meet the demands of multiple toilets flushing simultaneously, hence the need for residents to flush toilets repeatedly. This pump may have been the source of "banging" noises reported by the residents.

Findings

Biochemical oxygen demand (BOD) is an indicator of the organic "strength" of wastewater. It represents the amount of oxygen bacteria consumes over a five-day period. Although the monitoring data for Conservation Co-op demonstrated that its greywater had a significant BOD—an average of 130 mg/L (equivalent to low-strength domestic wastewater)—the treatment processes did not appear to take this into consideration. As a result, bacteria grew within the treatment system tanks, the distribution pipe and toilets. In the absence of a supplied oxygen source, bacteria quickly depletes any available oxygen in solution, creating anaerobic conditions within a storage tank and a distribution system. This was the cause of foul odours and black particles (clusters of bacteria) noted by residents. Bacteria could also be expected to grow on the surfaces of toilet tanks and bowls, increasing the need for frequent bowl cleaning.

Although an intermittent sand filter (ISF) can effectively remove BOD from wastewater, the slow sand filter and rapid sand filters tested in this project were ineffective for this purpose. They are more appropriate for filtering particulate material in potable water treatment applications. The multimedia pressure filter installed as part of the final treatment system was even less likely to reduce BOD.

The incorporation of a properly designed pressure tank to supply reused water to the distribution system could improve the effectiveness of toilet flushing and reduce the potential for noise. A pressure tank is a common component of domestic (potable) well water systems. A rubber bladder within the pressure tank provides a larger reservoir of pressurized water (i.e., more uniform pressure and flow) than could be achieved using the distribution pump and pipe alone. Furthermore, the storage capacity of the pressure tank bladder requires less frequent pumping, and hence reduces operation noise.

Recommendations and outcome

NovaTec recommended the following remedial measures to improve system performance and address the problems observed with the treatment system:

1. Add a biological treatment component to the process, in place of the multimedia filter, to reduce BOD concentration from 130 mg/L to less than 10 mg/L. NovaTec recommended an Orenco AdvanTex AX10 treatment system, given the restricted area available for biological treatment. This system is unique in terms of its small size (8' x 6' room) and simplicity of operation, in comparison to more conventional methods of biological treatment.

2. Add a pressure tank to the system to provide water to the reuse water distribution system. The existing distribution pump would transfer water from the treated water tank to the pressure tank, which would be sized to provide adequate flow/pressure to accommodate up to six toilets flushed simultaneously. The pressure tank would also significantly reduce or effectively eliminate any "banging" noise.

3. Replace the ozonation system with either a secondary chlorination or ultraviolet disinfection system to ensure that faecal coliform levels in the treated water are less than 2.2 MPN/100 mL (i.e., non-detectable). This would eliminate the hazardous conditions associated with ozone being ventilated into an equipment room or a basement area. While a chlorination system is less expensive and simpler to operate and maintain than an ultraviolet disinfection system, it may be less acceptable, as the smell of chlorine may be objectionable to some people.

4. Relocate the treatment system to an alternative location within the basement area. The limited area and ceiling height within the existing treatment room cannot accommodate the recommended treatment modifications. The existing raw greywater settling-equalization tanks would remain in the existing equipment room, as these tanks are conveniently connected to a sump, and it would be difficult to extend the greywater drainage pipe to the proposed new area for treatment. Relocation would require extensive plumbing and electrical/ control modifications.

One of the disadvantages of most biological treatment systems is that they generally require frequent operator attention as they generate significant quantities of bacteria that must be periodically removed and disposed of. Consequently, they are typically installed outside to provide more convenient access for solids removal.

The recommended AdvanTex AX10 treatment system is a biological filtration system that has been shown to generate a minimal amount of biosolids (waste bacteria) in comparison to other more conventional secondary treatment technologies. The recirculation tank and filter require little operator attention other than routine weekly visual inspection. The only mechanical component is a recirculation pump, which is connected to a control and alarm system. Accumulated biosolids would need to be pumped into the sewer system, about once every six months or less frequently.

The ultraviolet disinfection system requires routine monitoring and, most likely, weekly cleaning of the quartz tubing, which is a simple procedure requiring only 5 to 10 minutes.

The raw water equalization and treated water tanks should be inspected weekly, and they might require periodic cleaning to clear any potential bacterial or scum build-up along the walls.

The proposed changes to the treatment system were costed at $40,000, plus applicable taxes. This included the cost of supplying and installing the recommended biological treatment process, pressure tank and new water storage tank; relocating equipment to a new area of the basement; providing the necessary plumbing and power to the new area; and an allowance for engineering and overseeing equipment installation and commissioning.

Operating costs were expected to increase by about $70 per year for the biological treatment process and about $300 per year for the optional ultraviolet disinfection system. Overall, the changes were expected to decrease maintenance requirements from the original system, but requiring more maintenance than a building with standard plumbing.

In the end, Conservation Co-op decided against having a treatment system for the time being. In part, the co-op was concerned about replacement parts and costs. As well, the system required a greater amount of time than anticipated for ongoing maintenance, about two hours every week, as opposed to the previously assumed two or three hours per month. The project also revealed that initial training of maintenance staff was insufficient, with considerably more time needing to be devoted to this system.

Conclusion

The project at Conservation Co-op demonstrated a need for a more foolproof, less expensive, and low maintenance residential greywater treatment system. It underscored the need for more extensive maintenance training and the importance of not underestimating the time required for ongoing maintenance. In terms of a financial return on investment, this project showed that it may be more appropriate, at least in a research setting, to pursue the use of these systems where many more residential units are involved.

In short, Conservation Co-op helped identify a number of barriers that need to be overcome regarding domestic greywater treatment systems. These barriers are a combination of technology (suitable to do the job with no noise, easy installation and no smells or other problems), cost (purchase and replacement) and maintenance requirements.

With new, less expensive and better technologies continuing to emerge for greywater treatment, other systems with potential for residential use will soon be available for testing.

The following Technical Series Research Highlights available on CMHC's Web site offer additional information related to greywater systems and the Conservation Co-op:

01-112 Advancing the "Light Grey Option": Making Residential Greywater Reuse Happen

01-115 Commissioning Guide for the Toronto Healthy Houses Water Systems

00-140 Compendium of Research on the Conservation Co-op Building.

Project Manager: Sandra Baynes, Senior Researcher
Research Report: Conservation Co-op Greywater Treatment System Assessment, 2001
Research Consultant: Troy D. Vassos, NovaTec Consultants Inc.

Housing Research at CMHC

Under Part IX of the *National Housing Act*, the Government of Canada provides funds to CMHC to conduct research into the social, economic and technical aspects of housing and related fields, and to undertake the publishing and distribution of the results of this research.

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